Ms. Chirby's AP Biology Review Packet

Thank you Ms Chirby!

*****Note: The unit #'s and order are different for this packet than they are in our curriculum. Also, enzymes are included in the biochemistry unit on this packet, but we included them in the enzymes and cell respiration unit for our curriculum. OH WELL, WE CAN DEAL.*****

Unit 1: Evolution and Classification

Thinking Practice Questions

1. As a field researcher you are sent to the Arizona desert to study the prairie dog species C. ludivincianus to determine if the population is in Hardy-Weinberg equilibrium. Specifically, you are studying this population with respect to the gene that determines the coat color in C. ludivincianus. This trait is coded for by a single gene (the NDY6 gene) with two alleles (N, n) and is passed down from one generation to the next. After sampling 170 of these prairie dogs, you find that 36% of the C. ludivincianus population is homozygous recessive for coat color. Assuming that the population is in Hardy-Weinberg equilibrium…
   a. What is the allele frequency of the N allele?

$q^2 = 0.36 \rightarrow q = 0.6 \ldots$. $p + q = 1$ so $p =$ **0.4**

   b. What is the frequency of homozygous dominant prairie dogs?

$p^2 = (0.4)^2 =$ **0.16**

   c. What is the frequency of heterozygous prairie dogs?

$2pq = 2(0.4)(0.6) = 0.48$

   d. What conditions must be being satisfied for this population to be in HW equilibrium?

No natural selection, no sexual selection (random mating), no gene flow, no genetic drift, no mutation

2. Sixty flowering plants are planted in a flowerbed. Forty of the plants are red-flowering homozygous dominant. Twenty of the plants are white-flowering homozygous recessive. The plants naturally pollinate and reseed themselves for several years. In a subsequent year, 178 red-flowered plants, 190 pink-flowered plants, and 52 white-flowered plants are found in the flowerbed. Use a chi-square analysis to determine if the population is in Hardy-Weinberg equilibrium.

Total initial population size = 60

$q^2 = 20/60 = 1/3 \rightarrow q = 0.577 \rightarrow p = 0.423$

$p^2 = 0.179$

$2pq = 2(0.423)(0.577) = 0.488$

With a final population size of 420 (178+190+52), if the population is in HW equilibrium, the following values are expected (e)

Red flowered plants = 0.179 x 420 = 75

Pink flowered plants = 0.488 x 420 = 205

White flowered plants = 0.333 x 420 = 140

Chi square analysis

Null Hypothesis : The observed values for red-flowered plants, pink-flowered plants, and white-flowered plants are not significantly different from the expected values predicted by HW equilibrium.

Phenotype	o	e	$(o-e)^2 / e$
Red	178	75	141
Pink	190	205	1
White	52	140	192
		Sum = X^2	334

Probability (p)	Degrees of Freedom (df)				
	1	2	3	4	5
.05	3.84	5.99	7.82	9.49	11.1

The formula for Chi-squared is:

$$X^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

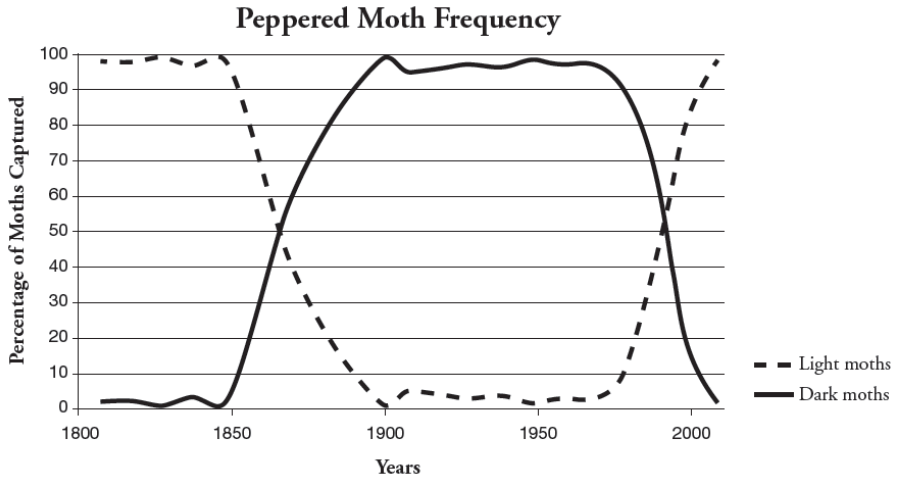
$\sum$ = the **sum of the values** (in this case, the differences, squared, divided by the number of expected)

With 2 degrees of freedom at a probability level of p = 0.05, our calculated chi square value (334) is above the critical value of 5.99. We reject the null hypothesis. Therefore, this population is not in HW equilibrium.

3. For the past 10 to 25 years, farmers have planted crop seeds that have been genetically modified to withstand treatment with a common weed killer called Roundup®. This allows the farmers to spray their fields to get rid of weeds without harming their crops. Recently, more and more farmers have discovered that their fields have Roundup-resistant pigweed growing along with their crop. Describe what has most likely happened over time to lead to this.

The non-resistant pigweed plants died, and the resistant plants survived and reproduced, leading to a higher percentage of resistant pigweed plants in later generations. The trait of pesticide resistance was "selected for" in the pigweed plant population.

4. Peppered moths have wings that vary in color, ranging from white to dark gray. During the Industrial Revolution through the mid-20th century, factories and power plants, which burned coal, produced large quantities of soot and smog. Near industrialized areas, black powder covered surfaces, including the moth habitat.
   a. Use this information to explain the changes seen in light and dark peppered moths from 1800-1950, as shown in the graph below.



Pollution darkened the trees, allowing the dark colored moths to camouflage and survive / reproduce better than the light moths.

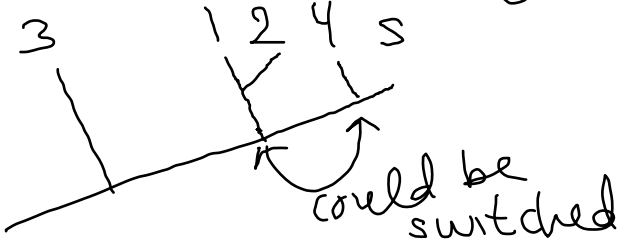
b. Propose an explanation for the return of the peppered moth population to more light than dark moths by the year 2000.

The pollution had been cleaned up, and the trees were light again, allowing the light colored moths to camouflage and survive / reproduce better than the dark moths.

5. Five new species of bacteria were discovered in Antarctic ice core samples. The nucleotide (base) sequences of rRNA subunits were determined for the new species. The table below shows the number of nucleotide differences between the species. Draw a phylogenetic tree indicating the relatedness of these 5 species.

Species	1	2	3	4	5
1	-	2	23	19	17
2		-	24	19	18
3			-	23	23
4				-	1
5					-

species 1 and 2 are closely Related
species 4 and 5 are closely Related
[ ] = species 3 is most distantly related



Long Response Question

Evolution is one of the unifying themes of biology. Evolution involves change in the frequencies of alleles in a population. For a particular genetic locus in a population, the frequency of the recessive allele (a) is 0.4 and the frequency of the dominant allele (A) is 0.6.

(a) What is the frequency of each genotype (AA, Aa, aa) in this population? What is the frequency of the dominant phenotype?

(b) How can the Hardy-Weinberg principle of genetic equilibrium be used to determine whether this population is evolving?

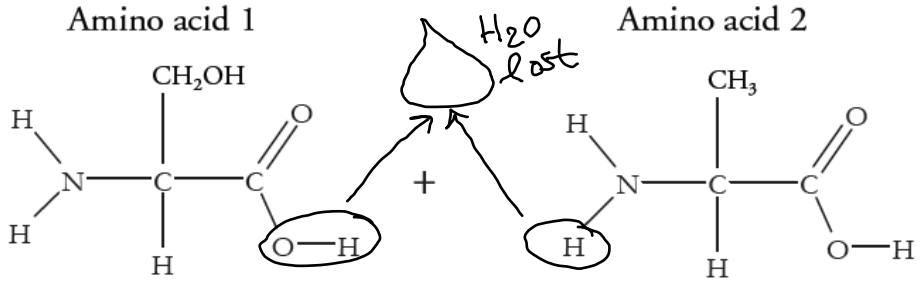
(c) Identify a particular environmental change and describe how it might alter allelic frequencies in this population. Explain which condition of the Hardy-Weinberg principle would not be met.

See the back of the packet for the rubric used to grade this question.

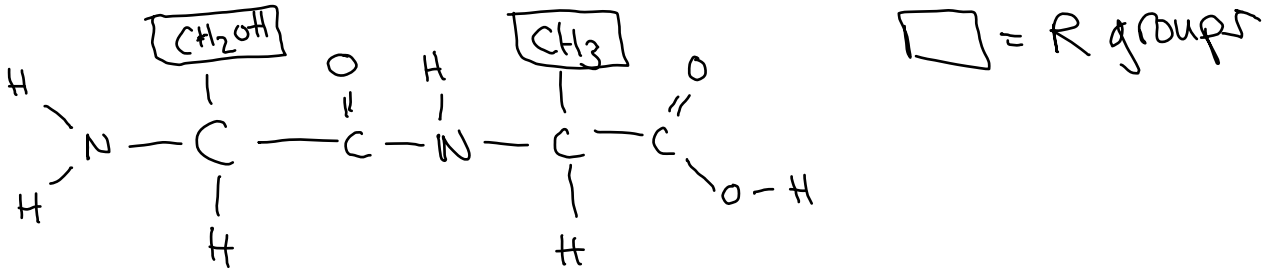
Unit 2: Biochemistry

Thinking Practice Questions

1. If the following molecules were to undergo a dehydration synthesis reaction, what molecules would result? **Circle** the parts of each amino acid that will interact and **draw** the resulting molecule.



2 amino acids are joined through dehydration synthesis to form a dipeptide.



2. Identify which of the six main elements (CHNOPS) are found in each of the four macromolecules (carbohydrates, lipids, proteins, and nucleic acids).

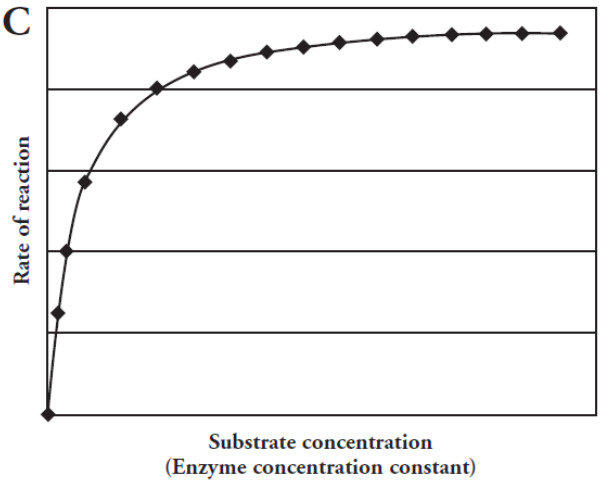
Carbohydrates = C,H,O (always in a 1:2:1 ratio)

Lipids = C,H,O (mostly C and H)

Proteins = C,H,O,N, and sometimes S (in R groups)

Nucleic Acids = C,H,O,N,P

3. Describe the relationship between substrate concentration and reaction rate shown in the graph below and propose an explanation for it.



As substrate concentration increases, the rate of reaction increases because there are more substrate molecules for the enzyme to act upon. However, once all enzymes are "saturated" with substrate molecules, the rate of reaction cannot increase further.

4. DNA polymerase from *T. aquaticus (Taq)* is used in PCR (polymerase chain reaction). PCR is a technique where millions of copies of DNA can be made from one original copy. In this method, the target DNA molecule is subjected to temperatures over 95 °C to make the double-stranded DNA separate. The temperature is then lowered slightly to allow primers to anneal before the *Taq* polymerase catalyzes the reactions to incorporate new nucleotides into the complementary strands. The cycle is then repeated over and over until there are millions of copies of the target DNA.

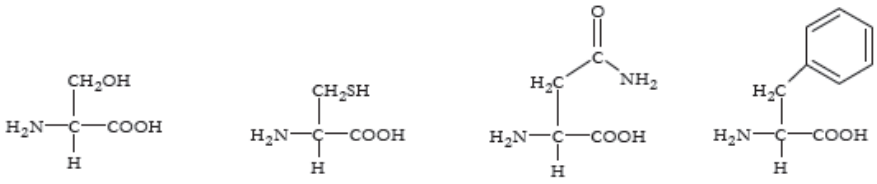
   a. Predict why this bacterial polymerase is used instead of a human polymerase.

It can withstand high temperatures without denaturing.

b. What would happen if you used a human polymerase in a series of PCR reactions?

The DNA strands will still separate and the primers will anneal, but the polymerase will be unable to copy the sequences because it has denatured.

5 Imagine a protein chain that includes the following amino acids among several others.



a. Which of the amino acids could form a hydrogen bond with another amino acid in the chain to stabilize the secondary structure of a β-pleated sheet?

b. Which of the amino acids could form disulfide bonds with another amino acid in the chain to stabilize the tertiary structure of the protein?

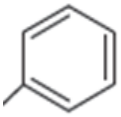
c. Which of the amino acids could participate in hydrophobic interactions with another amino acid in the chain to stabilize the tertiary structure of the protein?

a. In a hydrogen bond, an "H" on one molecule is attracted to an N, O, or F on another molecule. In protein secondary structure, hydrogen bonding occurs between non-adjacent amino (NH2) and carboxyl (COOH) groups. Because all the amino acids shown have an amino group and a carboxyl group (as do all amino acids), hydrogen bonding can occur between any of them.

b. Disulfide bonds occur between two amino acids that have R groups with the element sulfur. Two cysteine amino acids can form disulfide bonds with one another.

c. Hydrophobic interactions occur between nonpolar R groups in the tertiary structure of a protein. Cysteine and phenylalanine both have nonpolar R groups so hydrophobic interactions can form between these amino acids.

Note: The following structure is called a benzene ring, which only contains carbon and hydrogen atoms and is therefore nonpolar.



Short Response Question

Water is important for all living organisms. The functions of water are directly related to its physical properties. Describe how the properties of water contribute to TWO of the following:

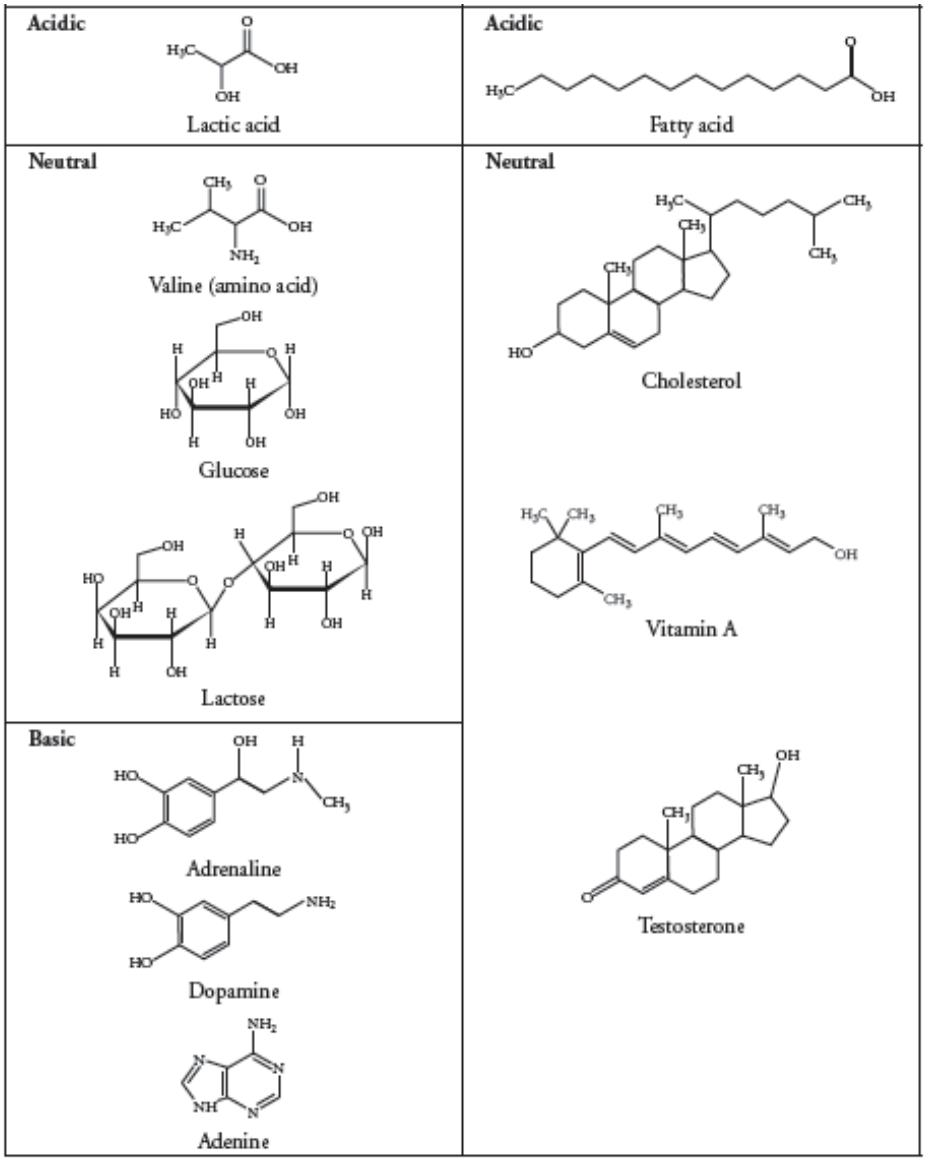
- Transpiration
- thermoregulation in endotherms
- plasma membrane structure

See the back of the packet for the rubric used to grade this question.

Unit 3: Cell Structure and Transport

Thinking Practice Questions

1. For each molecule shown to the right, answer the following, providing justifications for each:
   a. Is it polar or nonpolar?
   b. Is it hydrophobic or hydrophilic?
   c. In order to be transferred into a cell, would the molecule require a protein channel?



Cholesterol, vitamin A, testosterone, and the fatty acid are all mostly carbon and hydrogen atoms, which makes them nonpolar / hydrophobic. These molecules will not require a protein channel because they are nonpolar and can diffuse through the nonpolar tail region of the phospholipid bilayer (unless they are too large).

Lactic acid, valine, glucose, lactose, adrenaline, dopamine, and adenine all have significant proportions of atoms like oxygen or nitrogen, which make the molecule polar / hydrophilic. These molecules require a protein channel because they are polar and cannot diffuse through the nonpolar tail region of the phospholipid bilayer.

2. Biological systems rely heavily on the properties of water movement. Excretion, digestion, and blood pressure are just a few examples of situations where water balance is important. Suppose you have a semi-permeable membrane that ONLY water can pass. On one side of the membrane you have 0.1 M $CaCl_2$. On the other side of the membrane, you have 0.1 M Glucose. $CaCl_2$ ionizes in water to produce 3 ions. Glucose does not ionize in water.

0.1 M $CaCl_2$	0.1 M Glucose

Water potential equations

Water Potential (Ψ)

$\Psi = \Psi p + \Psi s$

The Solute Potential of the Solution

$\Psi s = -iCRT$

Ψp = pressure potential

Ψs = solute potential

The water potential will be equal to the solute potential of a solution in an open container, since the pressure potential of the solution in an open container is zero.

i = ionization constant (For sucrose this is 1.0 because sucrose does not ionize in water.)

C = molar concentration

R = pressure constant (R = 0.0831 liter bars/mole K)

T = temperature in Kelvin (273 + °C)

a. Calculate the water potential for each side of the membrane.

Solute potential for CaCl2 solution = -(3)(0.1)(0.0831)(298) = -7.43

Water potential for CaCl2 solution = -7.43 (open container so no pressure potential)

Solute potential for glucose solution = -(1)(0.1)(0.0831)(298) = -2.48

Water potential for glucose solution = -2.48 (open container so no pressure potential)

b. Describe which way water will move and explain your answer.

Water will move from the right side (glucose solution) to the left side (CaCl2 solution) because water moves from a high water potential (in this case -2.48) to a low water potential (in this case -7.43).

3. **Embedded proteins** are often found spanning the membrane of a cell or organelle. These proteins serve as channels for specific molecules to travel through the membrane, either into or out of the cell.

a. What sections of the embedded protein chain are most likely to contain amino acids with hydrophobic R-groups? Explain your reasoning.

b. What sections of the embedded protein chain are most likely to contain amino acids with hydrophilic R-groups? Explain your reasoning.

a. The sections of the protein chain inside the tail region of the phospholipid bilayer are most likely to contain amino acids with hydrophobic (nonpolar) R groups because these sections must be able to interact well with the hydrophobic phospholipid tails.

b. The sections of the protein chain outside the tail region (near the head regions) of the phospholipid bilayer are most likely to contain amino acids with hydrophilic (polar) R groups because these sections cannot interact well with the hydrophobic phospholipid tails but they can interact well with the hydrophilic phospholipid heads and the water on the outside and the inside of the cell.

4. Tay-Sachs disease is a human genetic abnormality that results in cells accumulating and becoming clogged with very large and complex lipids. Which cellular organelle must be involved in this condition?

If there are too many lipid molecules, this indicates that the enzyme used to break down these lipids is defective. Hydrolytic enzymes that are used to break down molecules are found in the lysosome, so it is likely that defective lysosomes are involved in Tay-Sacchs disease.

Units 4 and 5: Cell Energy (Cellular Respiration and Photosynthesis)

Thinking Practice Questions

1. The figure below outlines the process of cellular respiration. Glucose and oxygen are both reactants in this process.
    a. Describe the journey of a single carbon atom from glucose in cellular respiration

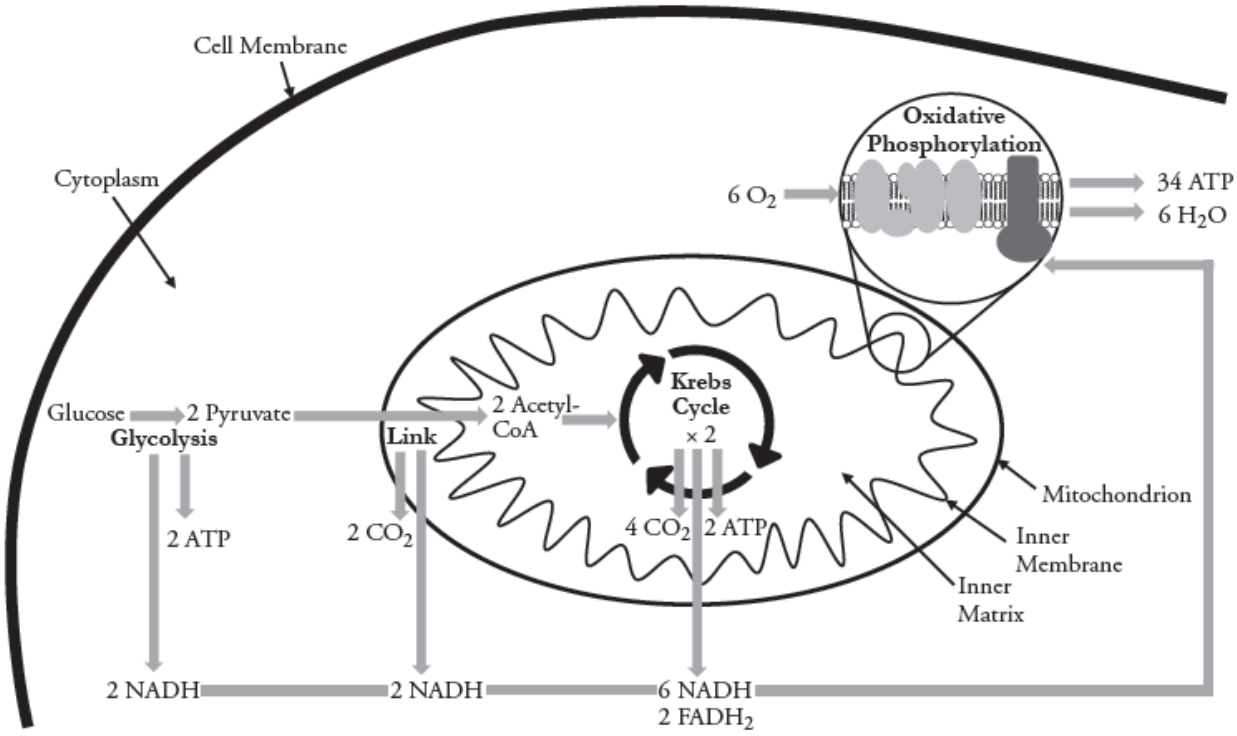
During cell respiration, the carbon is first found in glucose, then pyruvate, then acetyl coA or carbon dioxide

    b. Describe the journey of a single hydrogen atom from glucose in cellular respiration

During cell respiration, hydrogen is first found in glucose. As glucose is oxidized (loses electrons), H+ ions are released into the mitochondrial matrix. They are later pumped across the inner mitochondrial membrane into the intermembrane space by proton pumps. This creates an electrochemical gradient, which is later used for the creation of ATP through chemiosmosis.

    c. Describe the function of the oxygen molecules in cellular respiration

Oxygen is the final electron acceptor for electrons that travel through the electron transport chain. Once it accepts electrons and H+ ions, oxygen gas becomes water.



2. The figure below outlines the process of photosynthesis. Carbon dioxide and water are both reactants in this process.
    a. Describe the journey of a single hydrogen atom from water in photosynthesis.

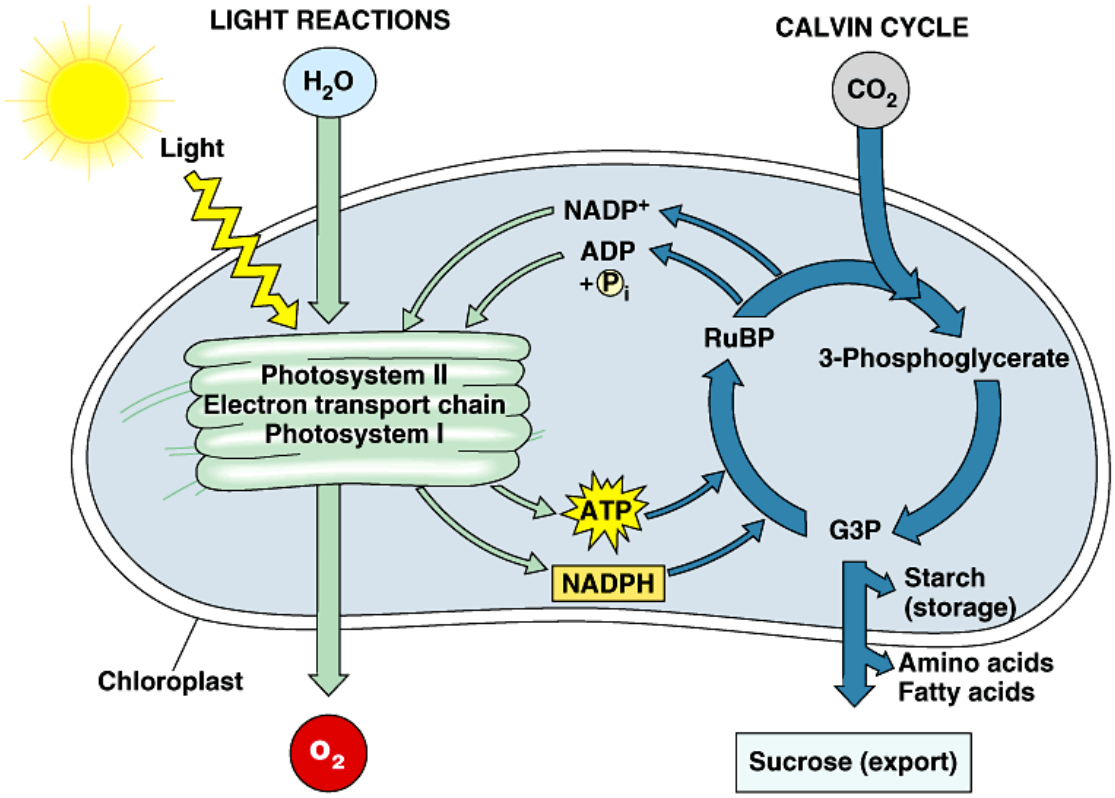
When water is split by sunlight to replace the electrons from chlorophyll, oxygen gas and protons (H+) are released. These protons are pumped across the thylakoid membrane during the electron transport chains of the light reactions. This creates an electrochemical gradient, which is later used for the creation of ATP through chemiosmosis.

    b. Describe the journey of a single oxygen atom from water in photosynthesis.

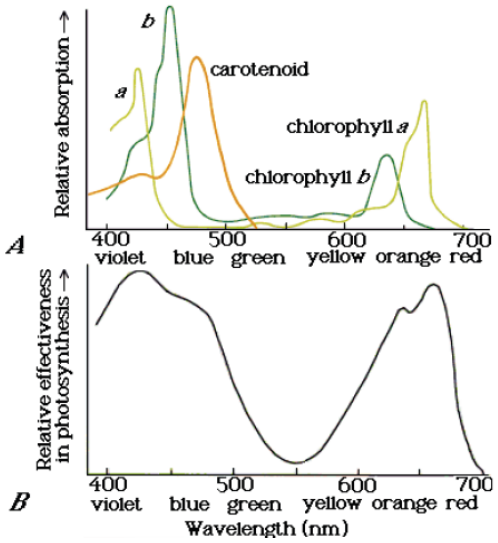
When water is split by sunlight, oxygen gas is released.

    c. Describe the journey of a carbon dioxide molecule in photosynthesis.

During the Calvin cycle, energy from ATP and NADPH created during the light reactions is used to create 3-carbon sugar molecules, which are later joined to form glucose.



3. The figures to the right display the absorption range for several different pigments found in plants (top) and the rate of photosynthesis at varying conditions of wavelength in one plant species (bottom):
    a. What color and wavelength of light is reflected by the plant species tested? How do you know?



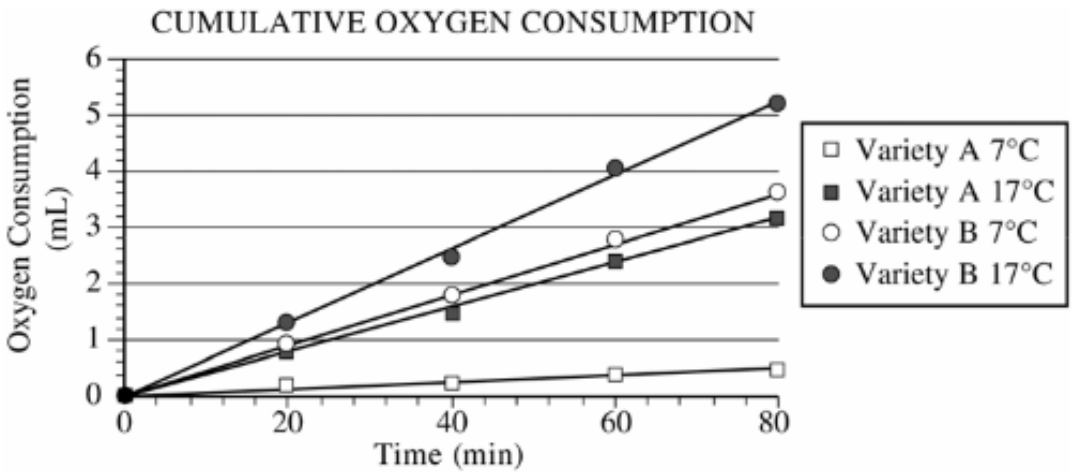
Green light has the lowest effectiveness in photosynthesis, meaning it is reflected, not absorbed by the plant.

    b. What wavelength(s) increase the rate of photosynthesis in the plant species tested? What pigment does this correspond to? How do you know?

Blue and red light have the highest effectiveness in photosynthesis, meaning they are absorbed by the plant. Chlorophylls a and b appear to be the most effective at using blue and red light.

Short Response Question

An agricultural biologist was evaluating two newly developed varieties of wheat as potential crops. In an experiment, seedlings were germinated on moist paper towels at 20°C for 48 hours. Oxygen consumption of the two-day-old seedlings was measured at different temperatures. The data are shown in the graph below.



In a second experiment, Variety A seedlings at 17°C were treated with a chemical that prevents NADH from being oxidized to NAD+. **Predict** the most likely effect of the chemical on metabolism and oxygen consumption of the treated seedlings. **Explain** your prediction.

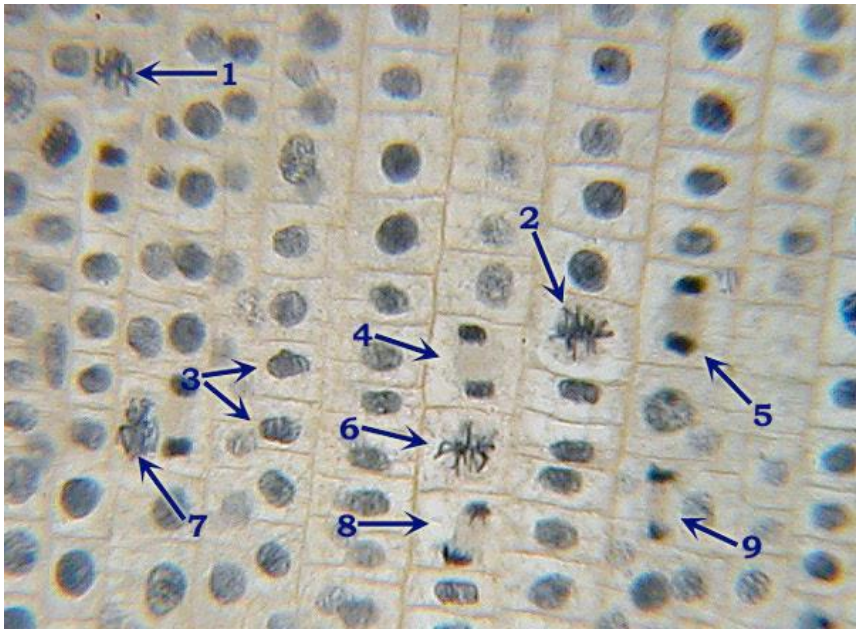
See the back of the packet for the rubric used to grade this question.

Units 6 and 7: Cell Division and Signaling

Thinking Practice Questions

1. Refer to the figure to the right.
    a. What process is being shown in this picture?

The cell cycle (interphase and the stages of cell division).



    b. What type of organism are these cells from? How do you know?

Plant; there are cell walls present.

    c. Identify a numbered cell for each of the four major stages of mitosis.

Prophase – 7
Metaphase – 6
Anaphase – 5
Telophase - 3

    d. In what stage are most of the cells in this image? What does this indicate about the amount of time spent in each phase of the cell cycle?

Interphase. A cell spends most of its life in interphase (not cell division).

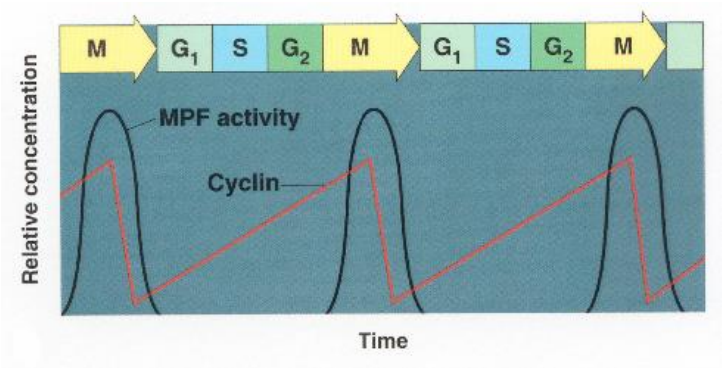
2. Paclitaxel is a chemotherapy drug used to treat a variety of cancers. Paclitaxel inhibits both assembly and disassembly of microtubules.
    a. Which phases in the cell cycle are affected by Paclitaxel? How does this drug inhibit the growth of cancer?

All stages of mitosis are affected by the drug because all stages involve synthesis, use, or breakdown of the spindle microtubules. If the drug inhibits mitosis, it will inhibit the growth of cancer because cancer involves abnormally high rates of mitosis.

    b. Paclitaxel affects not only cancer cells, but normal cells as well. Would the effects of Paclitaxel be seen first in organs that have quickly dividing cells (like the intestine and hair follicles) or in organs that have slow or nondividing cells (like muscles and the nervous system). Justify your reasoning.

Quickly dividing cells because it inhibits cell division.

3. Two students debate about proteins that regulate the cell cycle. One argues that MPF triggers the production of cyclin, while the other argues that cyclin triggers the production of MPF.



a. Based on the figure on the previous page, which statement is correct and why?

Cyclin triggers the production of MPF because cyclin levels rise before MPF activity begins to rise.

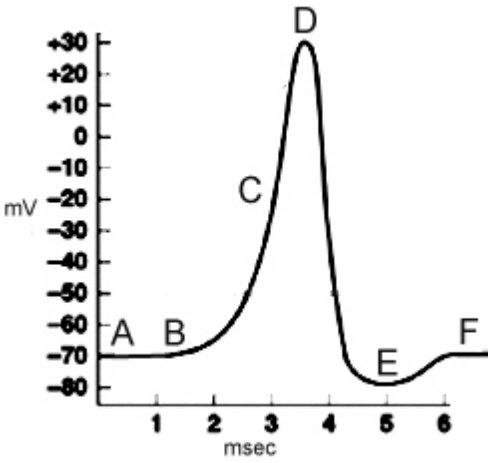
b. Propose a possible function of MPF, based on when it is produced in the cell cycle.

Because MPF activity is highest during mitosis, MPF is probably used to trigger some events involved in mitosis.

4. The following diagram shows an action potential of a neuron. For each question, you can answer with one letter or multiple letters.

a. At which letters would you find Na+ voltage gated channel OPEN?

C (allows depolarization of the neuron)



b. At which letter(s) would you find the Na+/K+ pump WORKING?

A (resting potential)

E and F (restabilishes resting potential)

c. At which letter(s) would you find K+ voltage gated channels OPEN?

D (allows repolarization / hyperpolarization of the neuron)

d. At point F, would there be a more positive charge on the INSIDE or OUTSIDE of the neuron?

Outside the neuron because the inside of the neuron has a negative resting potential (-70 mV)

e. At point B, would you find more Na+ on the INSIDE or OUTSIDE of the neuron?

Outside the neuron. The voltage-gated Na+ channels have not opened yet to allow Na+ to rush into the neuron during depolarization.

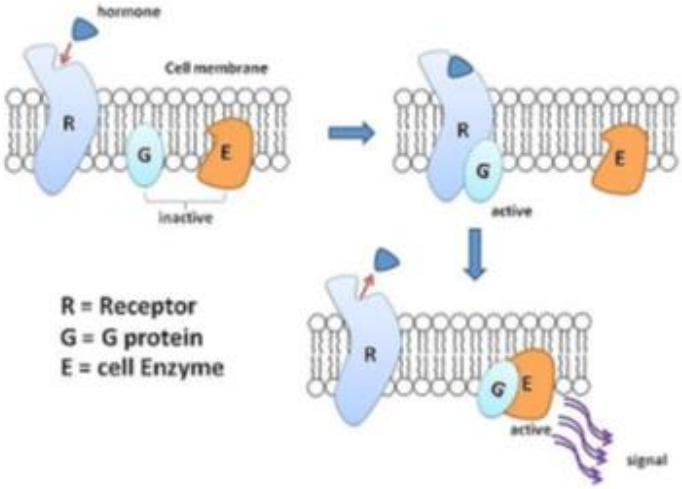
f. Tetrodotoxin is a neurotoxin that blocks Na+ voltage gated channels. How would the function of the neuron be altered by the presence of this toxin?

It will not be able to depolarize, preventing an action potential from being sent downt he neuron.

5. Refer to the diagram at the right to respond to the following questions.

a. Is the hormone hydrophobic or hydrophilic? How do you know?

Hydrophilic; it can't pass through the hydrophobic tail region of the phospholipid bilayer so it has to bind to a receptor on the surface of the plasma membrane.



b. Explain how the action of the hormone might be different if it could move through the cell membrane.

If it could move through the cell membrane, it would bind to an intracellular receptor, which could travel into the nucleus and

act as a transcripton factor stimulating the transcription of certain genes in the nucleus

c. Explain what is happening in this picture and make a prediction about what will be the end result in the cell to which this hormone has bound.

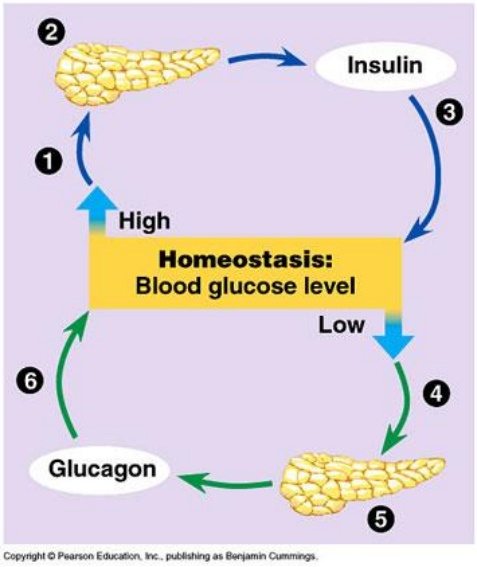
The plasma membrane receptor is a G-protein coupled receptor. It activates the G protein, which initiates a signal transduction pathway in the cell, most likely involving a phosphorylation cascade and/or the use of second messenger molecules.

6. One student described an action potential in a neuron by saying "As more gates open the concentration of sodium inside the cell increases and this causes even more gates to open." Is this an example of a positive or negative feedback loop? Justify your reasoning.

Positive feedback because the response (the increase in sodium concentration inside the cell) increases the stimulus (opening of gates).

7. The figure to the right shows the feedback mechanism for regulating blood glucose.
   a. Is this a positive or negative feedback loop? Explain your answer.

Negative feedback because the response (ex: insulin secretion) removes the stimulus (ex: high blood glucose).



   b. Individuals that suffer from Type I diabetes do not have functional insulin-producing cells. Describe how their blood will differ from that of a healthy individual after a glucose-rich meal.

Their blood glucose will remain high because they will not be able to produce insulin to lower blood glucose.

Short Response Question

Meiosis reduces chromosome number and rearranges genetic information. **Explain** how the reduction and rearrangement are accomplished in meiosis.

See the back of the packet for the rubric used to grade this question.

Units 8 and 9: Classical and Molecular Genetics

Thinking Practice Questions

1. You have performed a dihybrid cross of plants and got the following data: 206 purple tall, 65 white tall, 83 purple short, 30 white short. Perform a chi-square analysis to test the null hypothesis that both parents were heterozygous for the traits of color and height. Purple (A) is dominant to white (a), and tall (B) is dominant to short (b).

If both parents are heterozygous for both traits, their genotypes are AaBb x AaBb. In a dihybrid cross between two parents that are heterozygous for two traits, the expected offspring frequencies should be 9/16 purple tall, 3/16 white tall, 3/16 purple short, 1/16 white short.

Total population size = 206 + 65 + 83 + 30 = 384

Phenotype	Observed Values (o)	Expected Frequencies	Expected Values (e)	$(o-e)^2/e$
Purple tall	206	9/16	(9/16) x 384 = 216	$(206-216)^2 / 216 = 0.463$
White tall	65	3/16	(3/16) x 384 = 72	0.681
Purple short	83	3/16	(3/16) x 384 = 72	1.681
White short	30	1/16	(1/16) x 384 = 24	1.5
				Sum = X^2 = 4.33

Probability (p)	Degrees of Freedom (df)				
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.05	3.84	5.99	7.82	9.49	11.1

The formula for Chi-squared is:

$$X^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

$\sum$ = the **sum of the values** (in this case, the differences, squared, divided by the number of expected)

With 3 degrees of freedom at a probability level of p = 0.05, our calculated chi square value (4.33) is below the critical value of 7.82. We accept the null hypothesis. Therefore, the parents WERE both heterozygous for both traits.

2. Compare the two DNA sequences shown below. Transcribe them into mRNA and translate them into an amino acid sequence.

GTG CAC CTC ACA CCA GAG GAG (Normal Hemoglobin)

mRNA → CAC GUG GAG UGU GGU CUC CUC

amino acids → His Val Glu Cys Gly Leu Leu

GTG CAC CAC ACA CCA GTG GAG (Sickle Cell Hemoglobin)

mRNA → CAC GUG GUG UGU GGU CUC CUC

amino acids → His Val Val Cys Gly Leu Leu

a. Circle any differences there are in the DNA, RNA and amino acid sequences that might exist between these two sequences.

b. Identify the type of mutation that is represented AND EXPLAIN, IN DETAIL, what effect this would have on the protein/pigment.

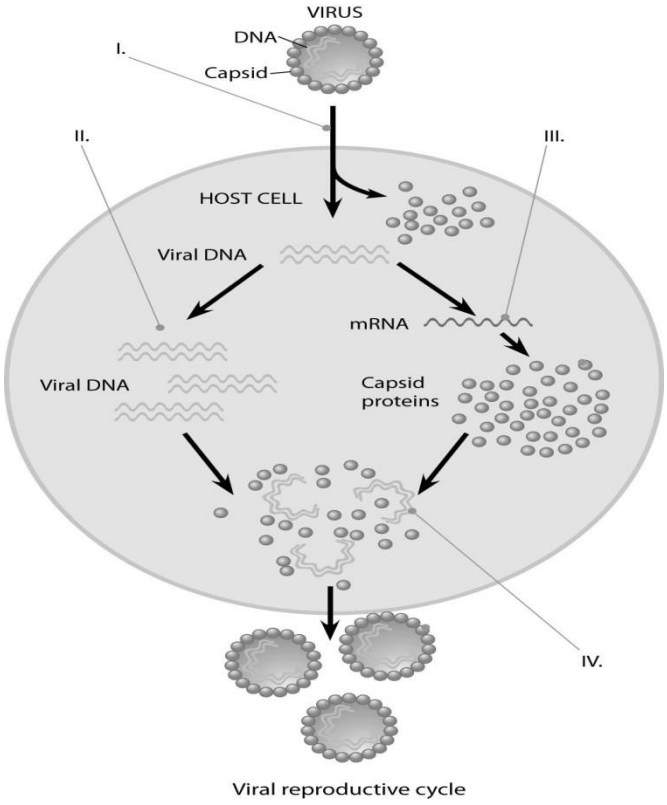
This is a point mutation where a T in the third DNA triplet is replaced by an A. This is a missense point mutation because it results in the change of one amino acid. This mutation changes the shape of the hemoglobin protein and causes it to clump together, resulting in red blood cells that are shaped like crescent moons (sickle-shaped). These oddly-shaped red blood cells tend to clog blood vessels.

3. In prokaryotic cells, translation begins before transcription is finished. Give two reasons why this would not be possible in eukaryotic cells.

Transcription occurs in the nucleus, whereas translation occurs in the bound ribosomes in the Rough ER or the free ribosomes in the cytoplasm. The completed mRNA created during transcription must leave the nucleus and travel to the ribosome before translation can occur.

4. Describe the processes occurring at each of the numbered positions (I, II, III, and IV) in the diagram to the right.

I. Virus injects its DNA into the host cell (leaves its capsid outside)
II. Viral DNA is replicated using host cell enzymes
III. Viral DNA is transcribed and translated into mRNA and then capsid proteins.
IV. Baby viruses are assembled using the newly synthesized viral DNA and capsid proteins. They then burst out of the host cell in a process called lysis.



Viral reproductive cycle

Short Response Question

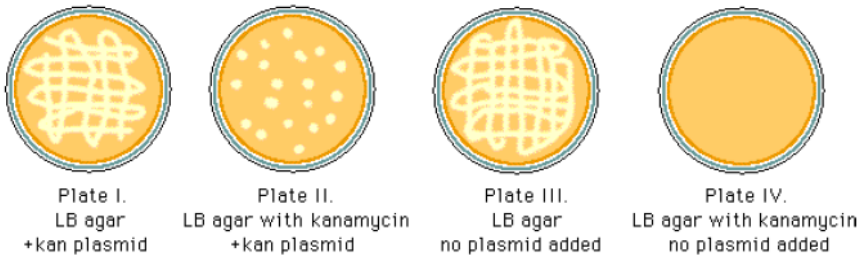
When DNA replicates, each strand of the original DNA molecule is used as a template for the synthesis of a second, complementary strand. Compare and contrast the replication of the two new strands, **listing** and **explaining** at least one similarity and one difference in the methods of synthesis. You may draw a diagram to help answer the question, but be sure to explain your diagram in your answer.

See the back of the packet for the rubric used to grade this question.

Units 10 and 11: Gene Regulation / Biotechnology and Organism Form / Function

Thinking Practice Questions

1. In a molecular biology laboratory, a student obtained competent *E. coli* cells and used a common transformation procedure to induce the uptake of plasmid DNA with a gene for resistance to the antibiotic kanamycin. The results below were obtained.



   a. What is the purpose of Plate IV?

Serves as a control to ensure that the non-transformed bacteria are killed by the antibiotic kanamycin.

   b. Explain the growth you see and the type of bacteria (transformed vs. non-transformed or both) that would be on Plate 1.

Both non-transformed and transformed bacteria will be able to survive on Plate I because it only has LB agar (bacteria food) and no antibiotic. Because there is nothing to prevent the growth of the bacteria, it will grow extensively (i.e. a bacterial lawn).

   c. Explain the growth you see and the type of bacteria (transformed vs. non-transformed or both) that would be on Plate II.

Only bacteria that are successfully transformed with the +kan plasmid will survive on Plate II because it has the antibiotic kanamycin. Because kanamycin will kill off all the nontransformed bacteria, only the successfully transformed bacteria will grow in isolated "colonies."

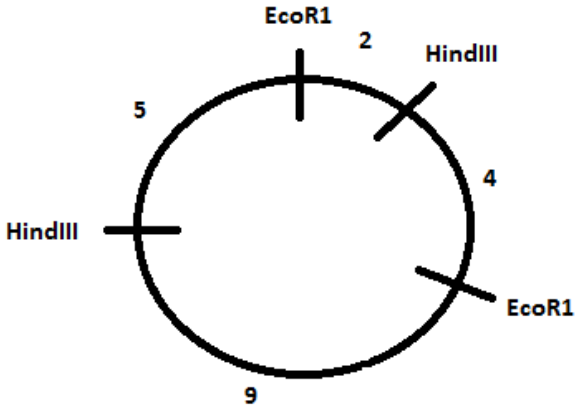
   d. If the student repeated the experiment, but the heat shock was unsuccessful and the plasmid was unable to be transformed, for which plates would growth be expected? Explain your answer.

Bacteria will only grow on plates where kanamycin is absent—plates I and III.

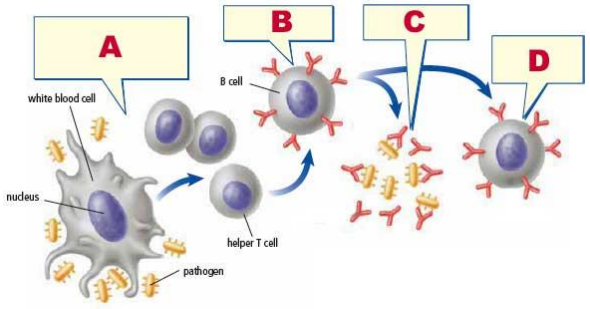
2. The restriction enzyme EcoRI cleaves double-stranded DNA at the sequence 5'-GAATTC-3' and the restriction enzyme HindIII cleaves at 5'-AAGCTT-3'. A 20 kb circular plasmid is digested with each enzyme individually and then in combination, and the resulting fragment sizes are determined by means of electrophoresis. The results are as follows:

EcoRI alone	fragments of 6 kb and 14 kb
HindIII alone	fragments of 7 kb and 13 kb
EcoRI and HindIII	fragments of 2kb, 4kb, 5 kb and 9kb

Make a diagram of the circular molecule and indicate the relative positions of the EcoRI and HindIII restriction sites. (Hint: place one EcoRI site at '12 o'clock' and position the remainder relative to this site.)

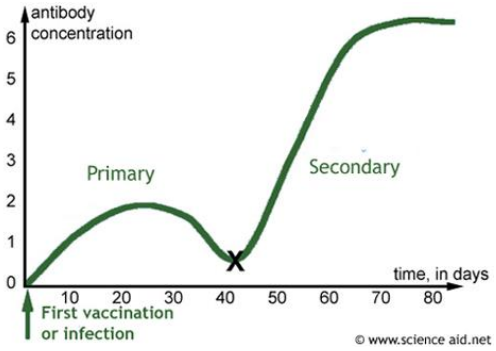


3. Refer to the images at the right to answer the following:
   a. Which immune response in shown: cell mediated or humoral? Explain how you know.



Humoral. The helper T cells induce the creation of B cells as part of the humoral response. Plasma B cells create antibodies that are used to cover the surface of pathogens to mark them for destruction. These pathogens are "naked" (have not yet infected human body) and are free floating in the body fluids (ex: blood and lymph).

   b. What are the "Y" shaped molecules called? What is their role in the immune response?



The Y-shaped molecules are called antibodies. (see part A for a description of antibody function.)

   c. Describe how the "Y" shaped molecules relate to the graph displayed.

Antibodies are creation in response to the primary infection. Once the pathogen is removed, the amount of antibodies decreases. Upon secondary exposure to the pathogen, memory B cells created during the primary exposure become plasma B cells which create even more antibodies than are synthesized during the first exposure.

Unit 12: Ecology

Thinking Practice Questions

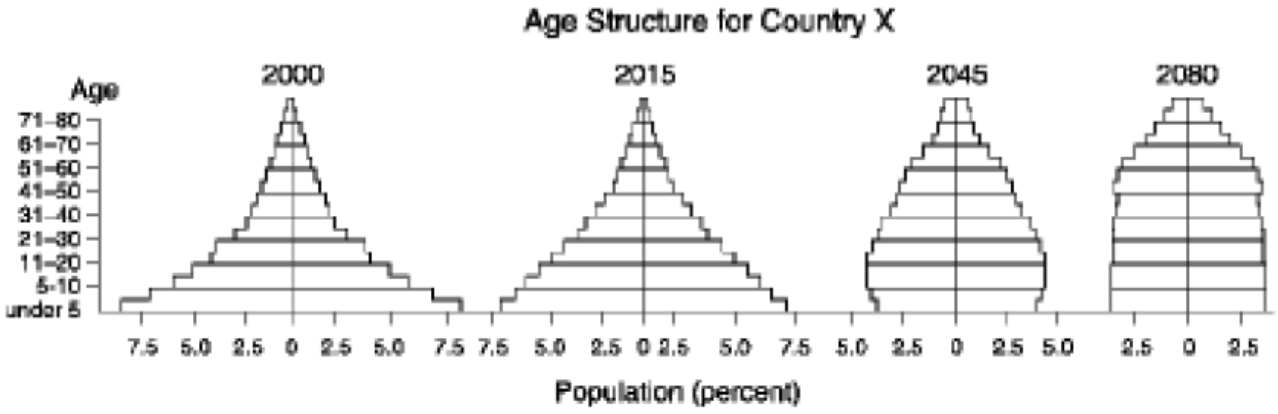
1. Invasive species are species that are introduced into an environment but are not naturally found in that environment. One example of an invasive species is the American gray squirrel, introduced into Britain at the end of the 18th century. Until 1876 the only native squirrel in Britain was the European red squirrel, which was found in deciduous and coniferous forests. By 1940 the gray squirrel had displaced the red squirrel across most of the British Isles, and by 1984 the red squirrel was only found in isolated coniferous woodland areas. After its initial introduction, the gray squirrel population increased rapidly; however, in recent years population sizes within specific environments have become stable.
    a. Explain why the newly-introduced gray squirrel initially showed rapid population growth and why the native red squirrel showed a population decline.

The gray squirrel must have been more successful at using the resources in Britain, and thus out-competed the red squirrel for these resources, resulting in an increase in the gray squirrel population and a decrease in the red squirrel population.

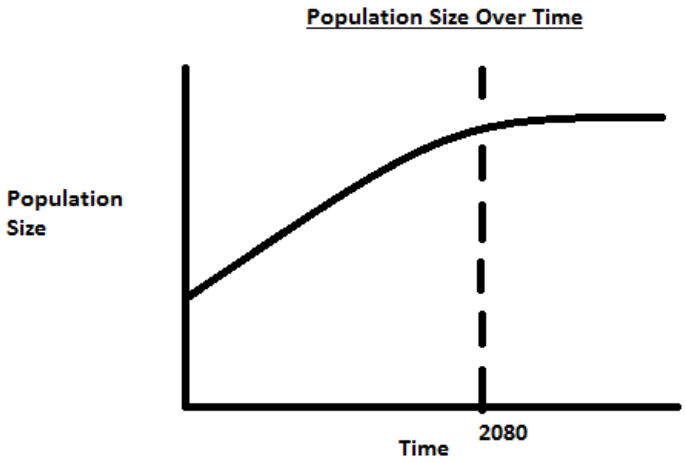
    b. Why has the population size of the gray squirrel become stable in recent years?

The gray squirrel population has reached its carrying capacity, the total population size that the environment can support.

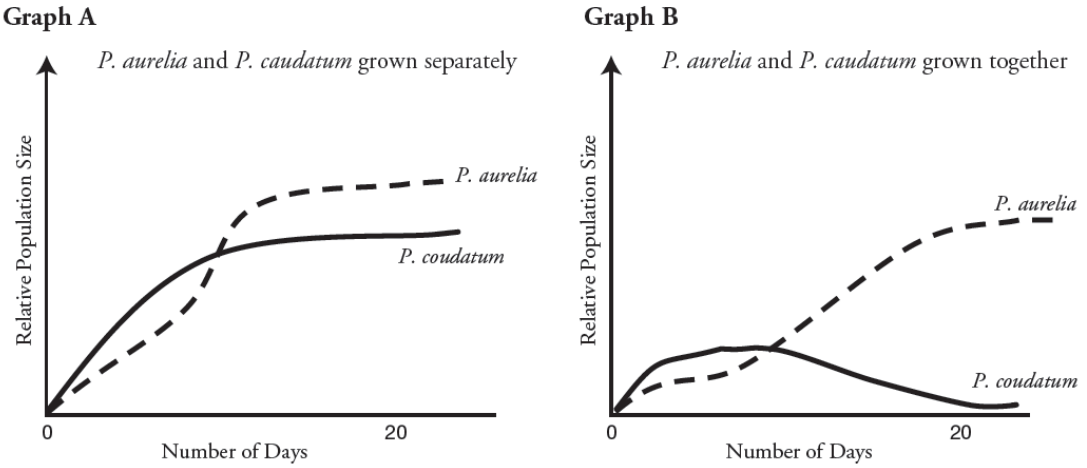
2. The first age structure graph below for country X shows the percent of the population in each age group for the year 2000. The remaining three graphs are projections of how the age structure of country X will change. From these age structure diagrams construct a graph of population size vs. time for 2000-2080 and justify your prediction.



Initially, the population is growing quickly (due to a high birth rate). The population is growing at a slower rate in 2080 because the birth rate is lower.



3. The graphs below display the growth rate for two species of bacteria when grown separately and together.



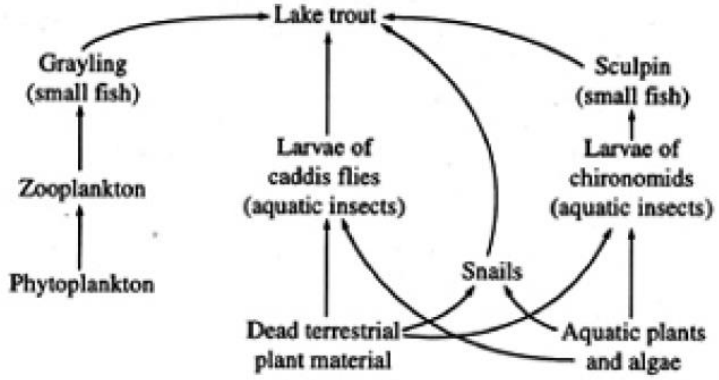
a. The population growth of which bacteria is more affected by growing conditions? Explain how you know.

P.caudatum. When a change occurs in the growing conditions (i.e. the bacteria a grown together), the size of the *P. caudatum* population decreases significantly, while the *P. aurelia* population stays at approximately the same size.

b. Using the information provided in the graphs, make a prediction as to why the bacteria identified in part a is more affected by growing conditions than the other bacteria.

P. caudatum is probably not as efficient at using the resources in the environment (i.e. petri dish) as *P. aurelia.*

4. Interdependence in nature is illustrated by the transfer of energy through trophic levels. The diagram below depicts the transfer of energy in a food web of an Arctic lake located in Alaska.



a. Identify an organism from each of the 5 trophic levels (producer, primary consumer, secondary consumer, teritiary consumer and decomposer) and explain how energy is obtained at each level.

Phytoplankton – producer (uses sunlight to make energy-rich molecules like glucose)
Zooplankton – primary consumer (eats phytoplankton)
Grayling – secondary consumer (eats zooplankton)
Lake trout – tertiary consumer (eats grayling)
Larvae of caddis flies – decomposer (eats dead plants and recycles nutrients into environment)

b. Describe the efficiency of energy transfer between trophic levels of this food web.

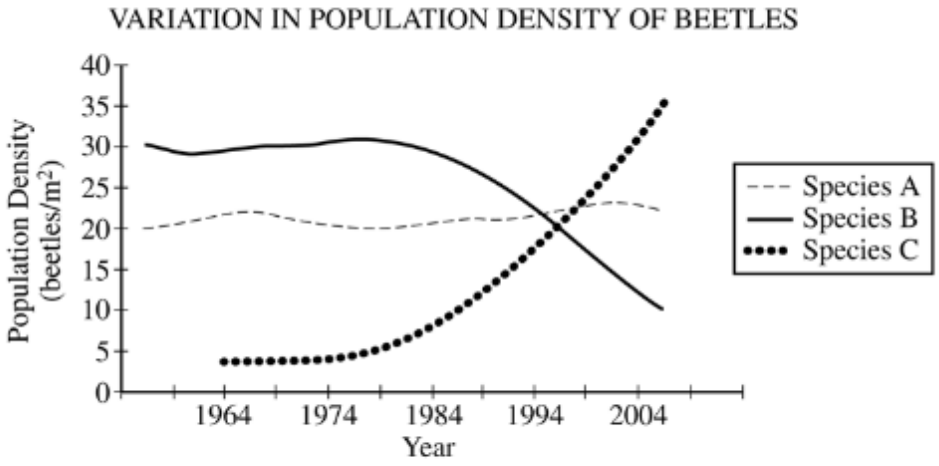
Only 10% of the energy from one level is transferred to the next trophic level.

c. Explain how the amount of energy available at each trophic level affects the size of each population.

Due to the inefficiency of energy transfer, a large population of producers can only support a small population of consumers.

d. If all of the Sculpin in this ecosystem were removed, predict how it would impact the following and explain each prediction:
   - The population of lake trout – the size of the lake trout population will decrease because they are losing a food source
   - The population of snails – the size of the snail population will decrease because they will be one of the main prey species for the lake trout
   - The population of algae – the size of the algae population will decrease because the Sculpin population's prey (ex: larvae of chironomids) will become more abundant. These prey species will eat more algae.
   - The amount of oxygen produced in the ecosystem – If the algae population is decreasing, the amount of oxygen produced will decrease because algae are a major producer / photosynthesizer in the environment.
   - The amount of light energy absorbed by the ecosystem – If the algae population is decreasing, the amount of light energy absorbed will decrease because algae are a major producer / photosynthesizer in the environment.

Long Response Question



According to fossil records and recent published observations, two species of leaf-eating beetles (species A and B) have existed on an isolated island in the Pacific Ocean for over 100,000 years. In 1964 a third species of leaf-eating beetle (species C) was accidentally introduced on the island. The population size of each species has been regularly monitored as shown in the graph above.

(a) **Propose** an explanation for the pattern of population density observed in species C.

(b) **Describe** the effect that the introduction of beetle species C has had on the population density of species A and species B. **Propose** an explanation for the patterns of population density observed in species A and in species B.

(c) **Predict** the population density of species C in 2014. Provide a biological explanation for your prediction.

(d) **Explain** why invasive species are often successful in colonizing new habitats.

See the back of the packet for the rubric used to grade this question.

Short and Long Response Rubrics

Evolution and Classification Short Response

(a) What is the frequency of each genotype (*AA*, *Aa*, *aa*) in this population? What is the frequency of the dominant phenotype?

Calculations **(4 points maximum)**

- Frequency *AA* = .36
- Frequency *Aa* = .48
- Frequency *aa* = .16
- Frequency dominant phenotype = .84

(Correct equation needed for credit if one of calculated numbers is wrong.)

(b) How can the Hardy-Weinberg principle of genetic equilibrium be used to determine whether this population is evolving?

Evolving population **(2 points maximum)**

- Allelic frequency changes or five conditions that do not change if population is not evolving
- Means of measurement/detection

(c) Identify a particular environmental change and describe how it might alter allelic frequencies in this population.

Explain which condition of the Hardy-Weinberg principle would not be met. **(4 points maximum)**

- Environmental change identified **(1 point)** (first one scored)
- Explanation of how allelic frequency changed **(1–2 points)**
- Which Hardy-Weinberg condition not met **(1 point)**

Biochemistry Short Response

(a) 4 point maximum

2 points for each process / one point per category in the context of linking property to contribution

Process	Property	Contribution to Process
Transpiration	polarity/cohesiveness	water movement
	high heat of vaporization	reduces water loss
	water potential	water movement
Thermoregulation	high heat of vaporization	evaporative cooling
	high specific heat	heat buffer
Plasma membrane	polarity	arrangement of phospholipids

Cell Energy Short Response

Prediction (1 point each; 2 points maximum)

- Metabolism/respiration stops/declines/decreases/slows down.
- Oxygen consumption stops/declines/decreases/slows down.

Explanation (1 point each; 3 points maximum)

- Glycolysis/Krebs cycle/ETC will stop.
- ATP levels will drop/decline/decrease.
- Oxygen cannot accept electrons from ETC.

Cell Division and Signaling Short Response

(a) **Explain** how the reduction and rearrangement are accomplished in meiosis.
(5 points maximum)

REDUCTION
1 point: **(homologous) chromosomes pair, then separate** and move to opposite poles during 1st meiotic division
1 point: **chromatids separate** during 2nd meiotic division

OR 1 point: two rounds of cell (nuclear) division but only one replication of the chromosomes

REARRANGEMENT
1 point: **crossing over** (in proper context)
1 point: **random alignment (independent assortment)** of tetrads
1 point: **elaboration (e.g.: correct mechanism/description or consequences** of one of the above) *

*NOTE: Diagrams that are clearly labeled and are described in the essay portion are acceptable and may receive a point

Classical and Molecular Genetics Short Response

SIMILARITIES 2 POINTS MAXIMUM 1 point for similarity, 1 point for elaboration (in parentheses)	• Synthesize DNA in 5' to 3' direction (DNA polymerase III can only work in one direction) • Use RNA primers to initiate replication (primase, DNA polymerase III must have a started sequence to be functional) • Both have RNA primers replaced with DNA (DNA polymerase I)
DIFFERENCES 2 POINTS MAXIMUM 2 points for difference including description of both strands	• One strand is synthesized as one, continuous strand (leading strand), while the other is synthesized in fragments (lagging strand). • Lagging strand must use ligase to connect segments of DNA, while leading strand does not require use of this enzyme.

Ecology Long Response

(a) **Propose** an explanation for the pattern of population density observed in species C. **[3 points]**
1. Description of curve [1 point]: Type of growth is exponential growth (logarithmic or J-shaped curve acceptable).
2. Explanation must describe the growth using an understanding of [1 point each, 2 points maximum]:
   - Lack of limiting factors
   - Low competition
   - Abundant food
   - Low predation
   - Ideal environmental conditions (habitat, temperature, moisture, etc.)
   - Access to mates

(b) **Describe** the effect that the introduction of beetle species C has had on the population density of species A and species B. **Propose** an explanation for the patterns of population density observed in species A and in species B. **[4 points]**
1. Describe effect [1 point]: Species C has had little or **no effect** on species A; however, as **species C increases, B decreases. Both lines must be addressed for the point.**
2. Explanation for species A or dashed line [1 point]: **No or little competition** (No niche overlap).
3. Explanation for species B or solid line [1 point]: **Competition or Niche overlap**.
4. Identification of the niche **"Competitive Exclusion Principle"** [1 point]: by name or description.

(c) **Predict** the population density of species C in 2014. Provide a biological **explanation** for your prediction. **[2 points]**
1. Prediction [1 point]: The population will **increase, decrease, or stabilize (level off)**.
2. Explanation [1 point]: Tie a correct explanation to the prediction.
   - **Increase**—tie to abundant resources and freedom from competition.
   - **Decrease**—tie to exhaustion of a key resource or density-dependent cause.
   - **Stabilize or level off**—tie to carrying capacity or a limiting resource.

(d) **Explain** why invasive species are often successful in colonizing new habitats. **[2 points—from either or both areas below]**
1. They have **lost a controlling population factor** from their original habitat: predator, pathogen, or parasite.
2. They **have a novel evolutionary advantage** brought to the island from their original habitat: an aspect that provides an advantage—a chemical defense, flight advantage, novel enzyme, etc.